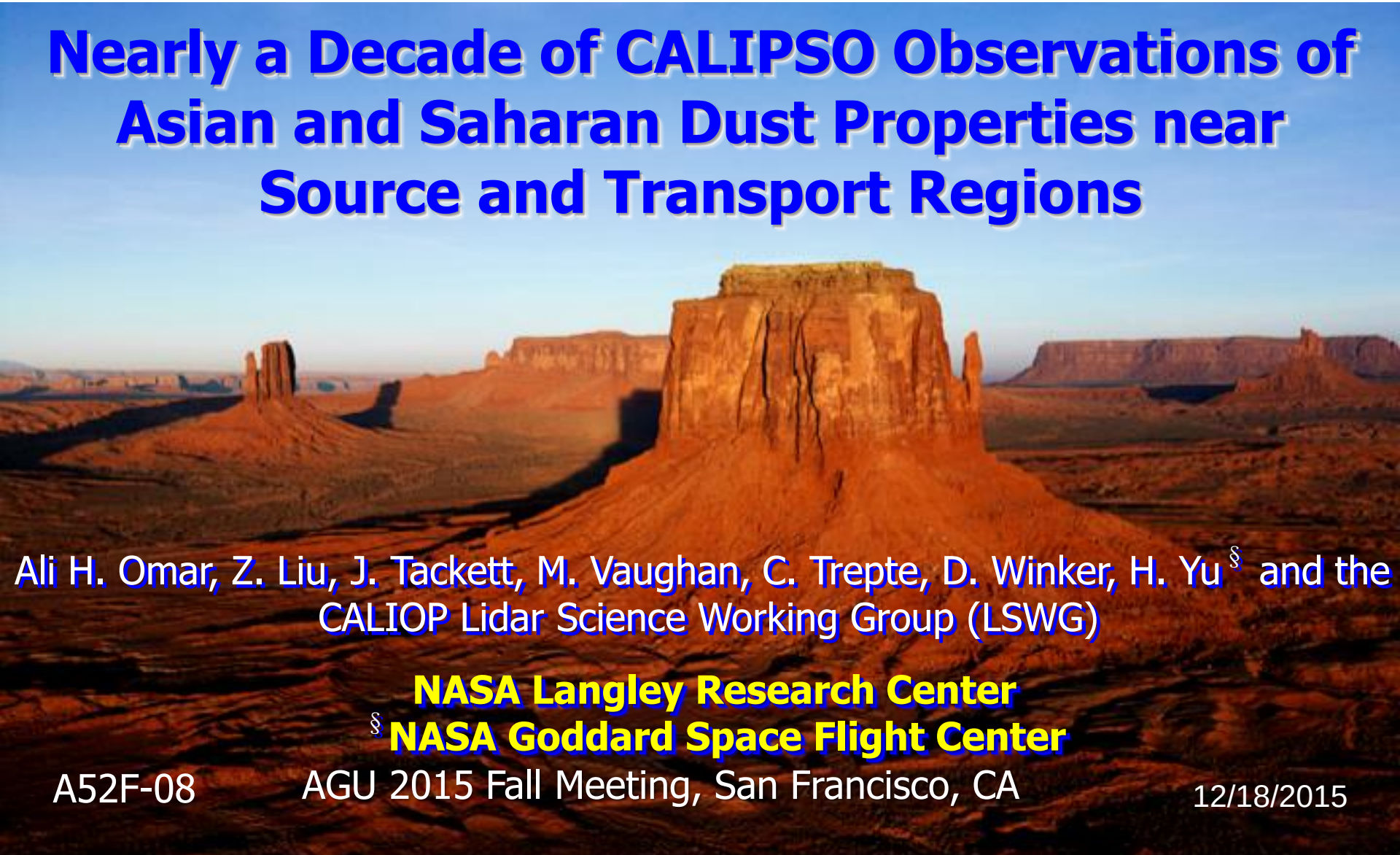
Nearly a Decade of CALIPSO Observations of Asian and Saharan Dust Properties near Source and Transport Regions



Ali H. Omar, Z. Liu, J. Tackett, M. Vaughan, C. Trepte, D. Winker, H. Yu[§] and the CALIOP Lidar Science Working Group (LSWG)

NASA Langley Research Center

[§] **NASA Goddard Space Flight Center**

A52F-08 AGU 2015 Fall Meeting, San Francisco, CA 12/18/2015

Dust Studies: Motivation

Observations suggest a doubling of dust over much of the globe during the 20th century (Mahowald et al., 2010)

Contributes to the aerosol direct and indirect radiative forcing

Affects African Easterly Waves and the development of tropical storms

Dust-radiation interactions are known to enhance convective strength

Dust is a source of nutrients for both phytoplankton (Fe) and the Amazon basin (P) [Yu et al. 2015]

Dust emission rates have increased in North Africa since 1950's (Mukhopadhyay and Kreycik, 2008)

CALIPSO's measurements of dust properties are robust and the length of the record is significant both seasonally and inter-annually

Measurements useful for assimilation (into) and validation of dust transport models

Outline

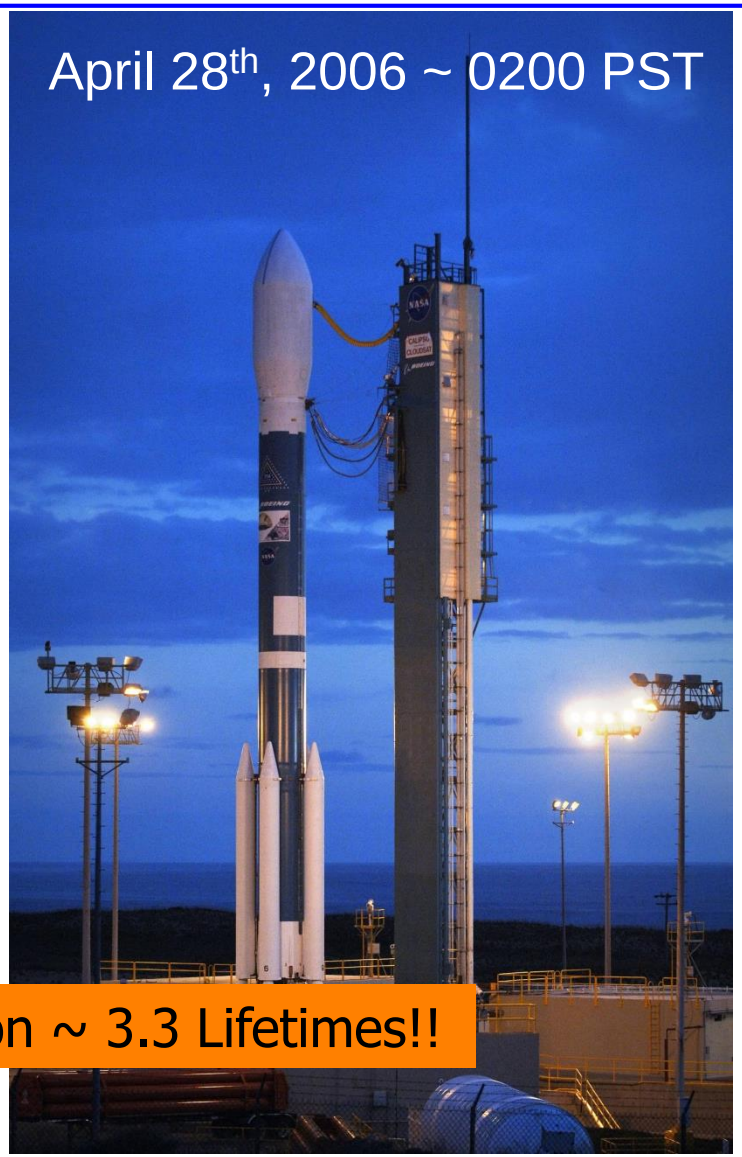
CALIPSO's automated detection of clouds and aerosols

Product description

Climatologies of dust distributions (2006-2013)

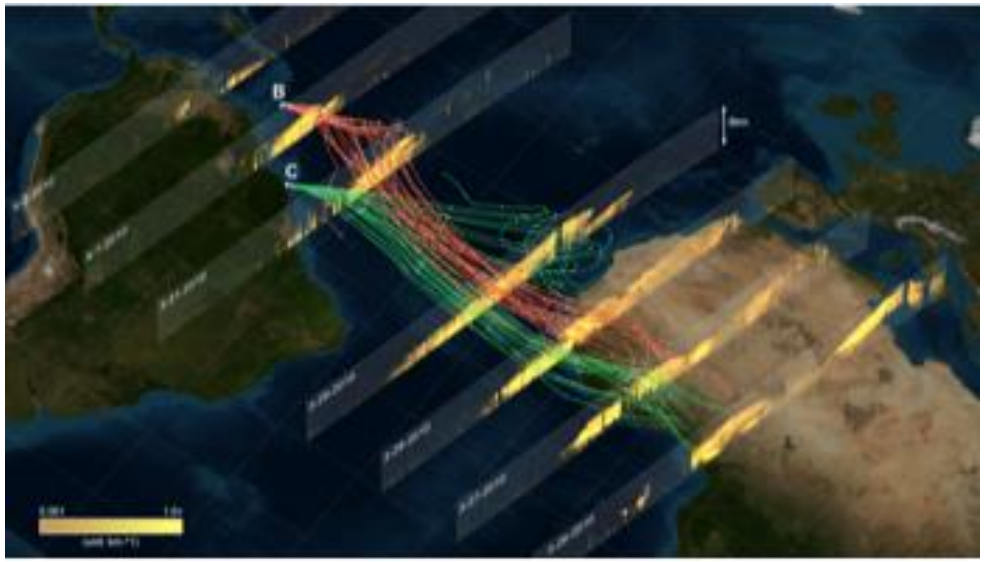
Optical characteristics of the dust layers in source and transport regions

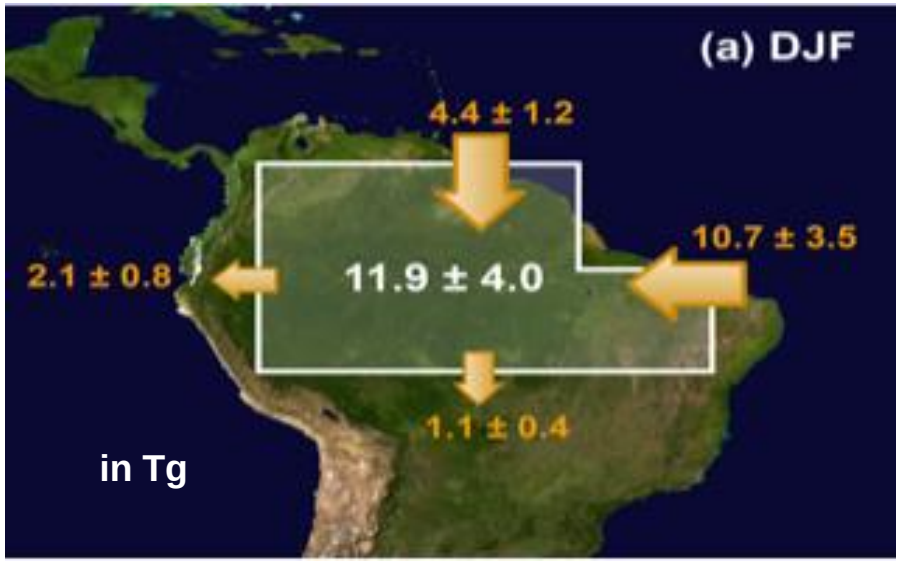
Above cloud retrievals of dust properties



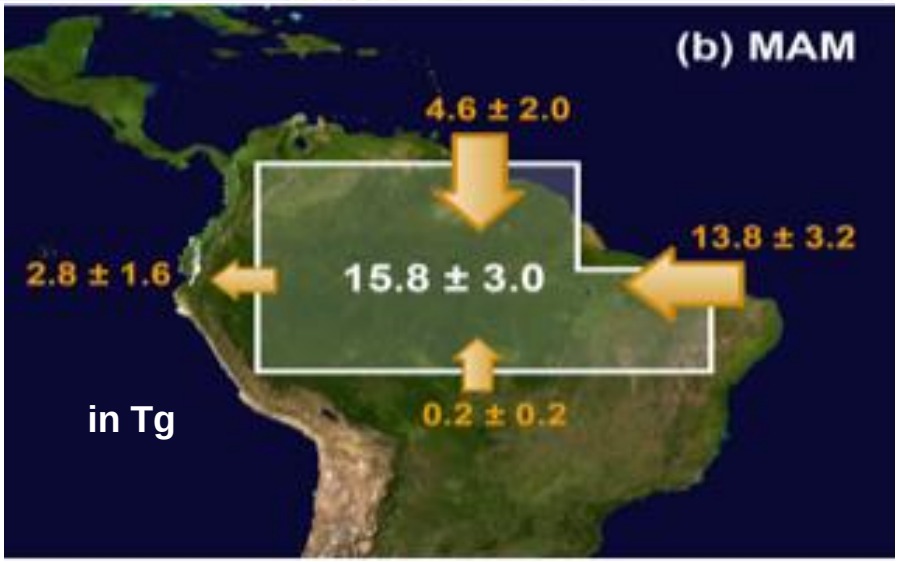
CALIPSO is in its 10th year of a 3 year mission ~ 3.3 Lifetimes!!

Saharan Dust Transport to the Amazon Rainforest



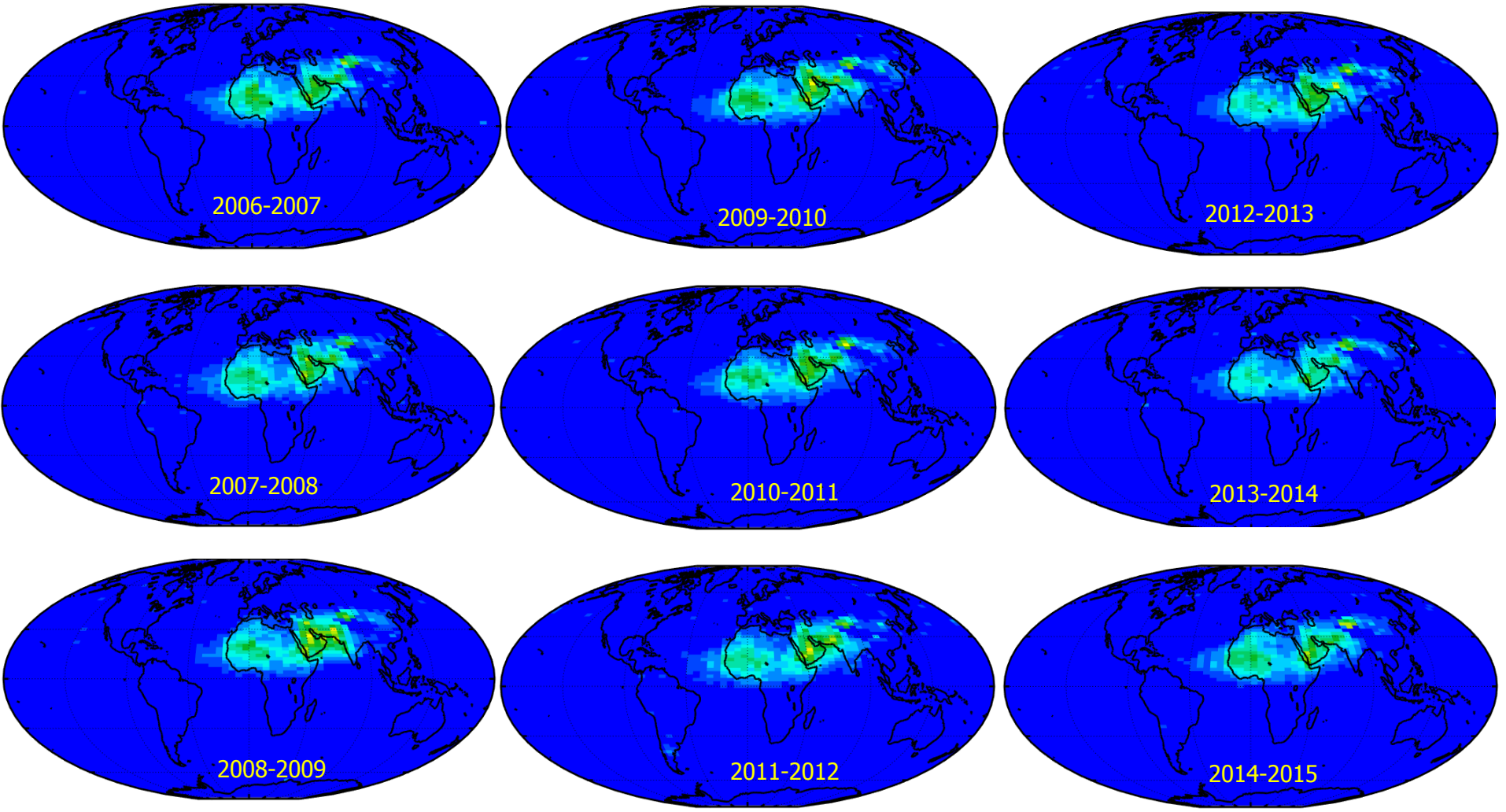


- CALIPSO lidar reveals the 3-D characteristics of dust transport across Atlantic Ocean.
- We used 2007-2013 CALIPSO data to estimate dust import into and export from Amazon Basin.
- 27.7 million tons of dust is deposited in the Amazon rainforest annually.
- The Saharan dust feeds the Amazon rainforest with an estimated 22,000 tons of phosphorus, replenishing the leak of this plant-essential nutrient by rains and flooding.

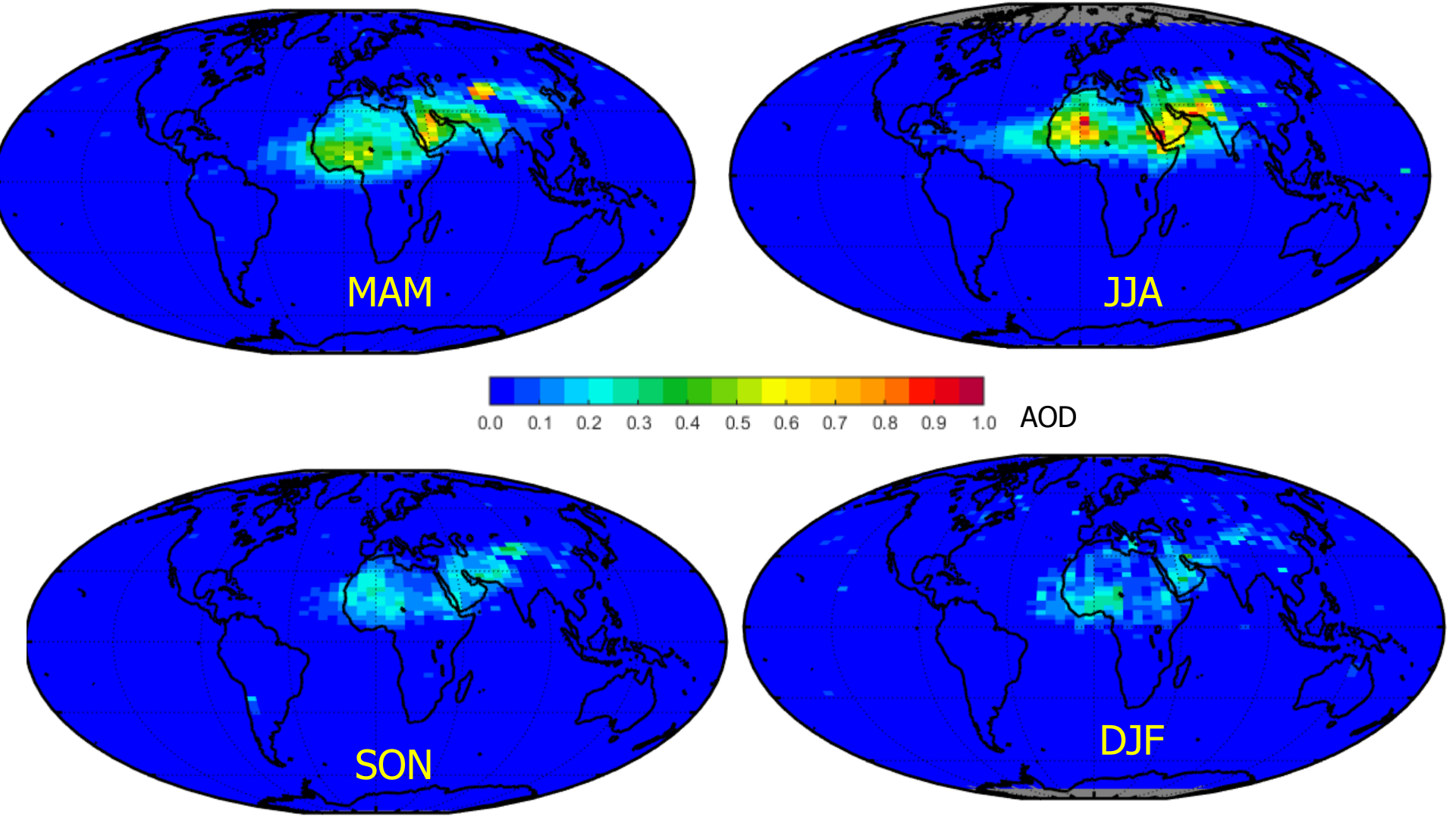


Yu et al., GRL 2015

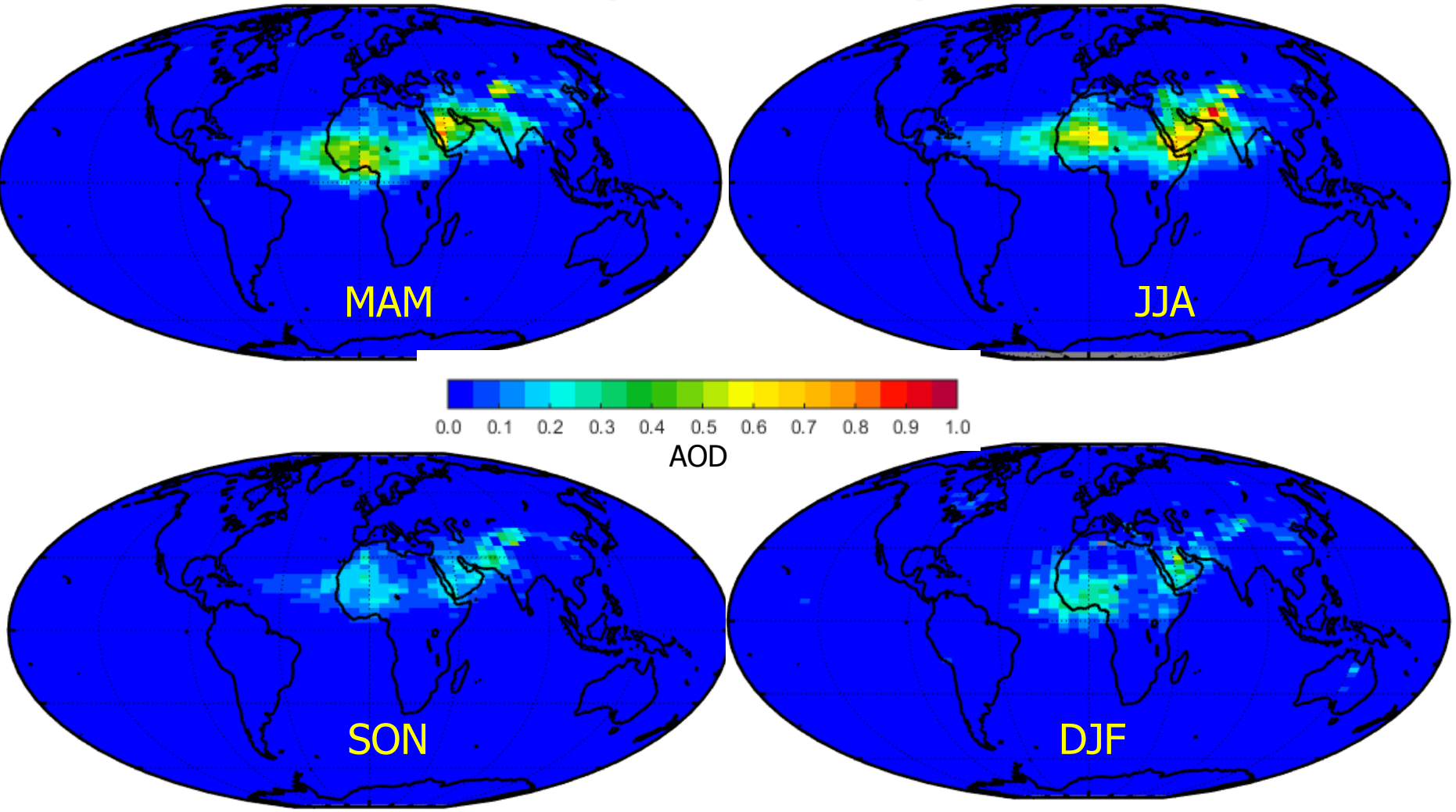
Mean Annual Nighttime Dust AOD (Jun –May)



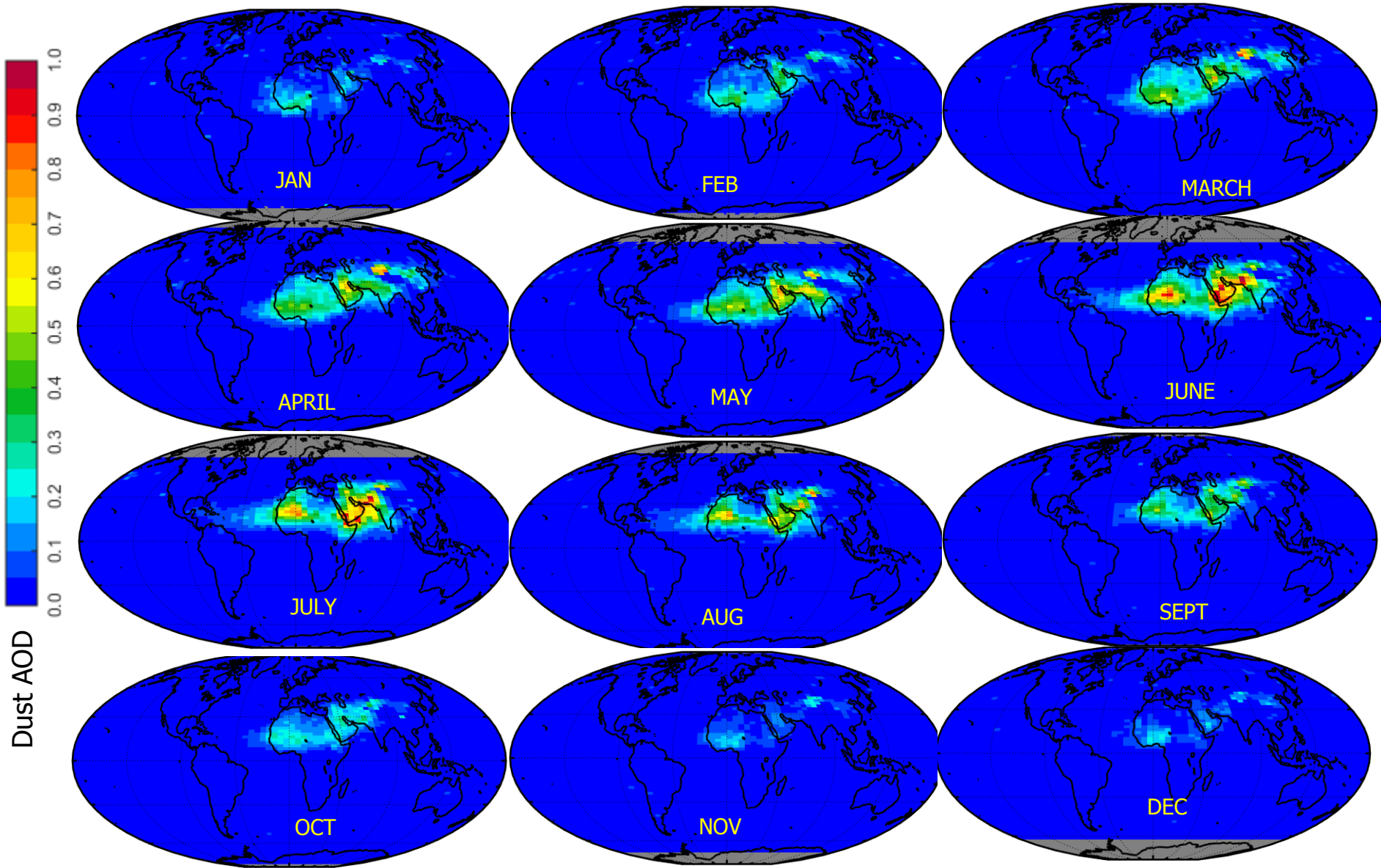
Mean Seasonal Dust Nighttime Dust AOD (2006-2015)



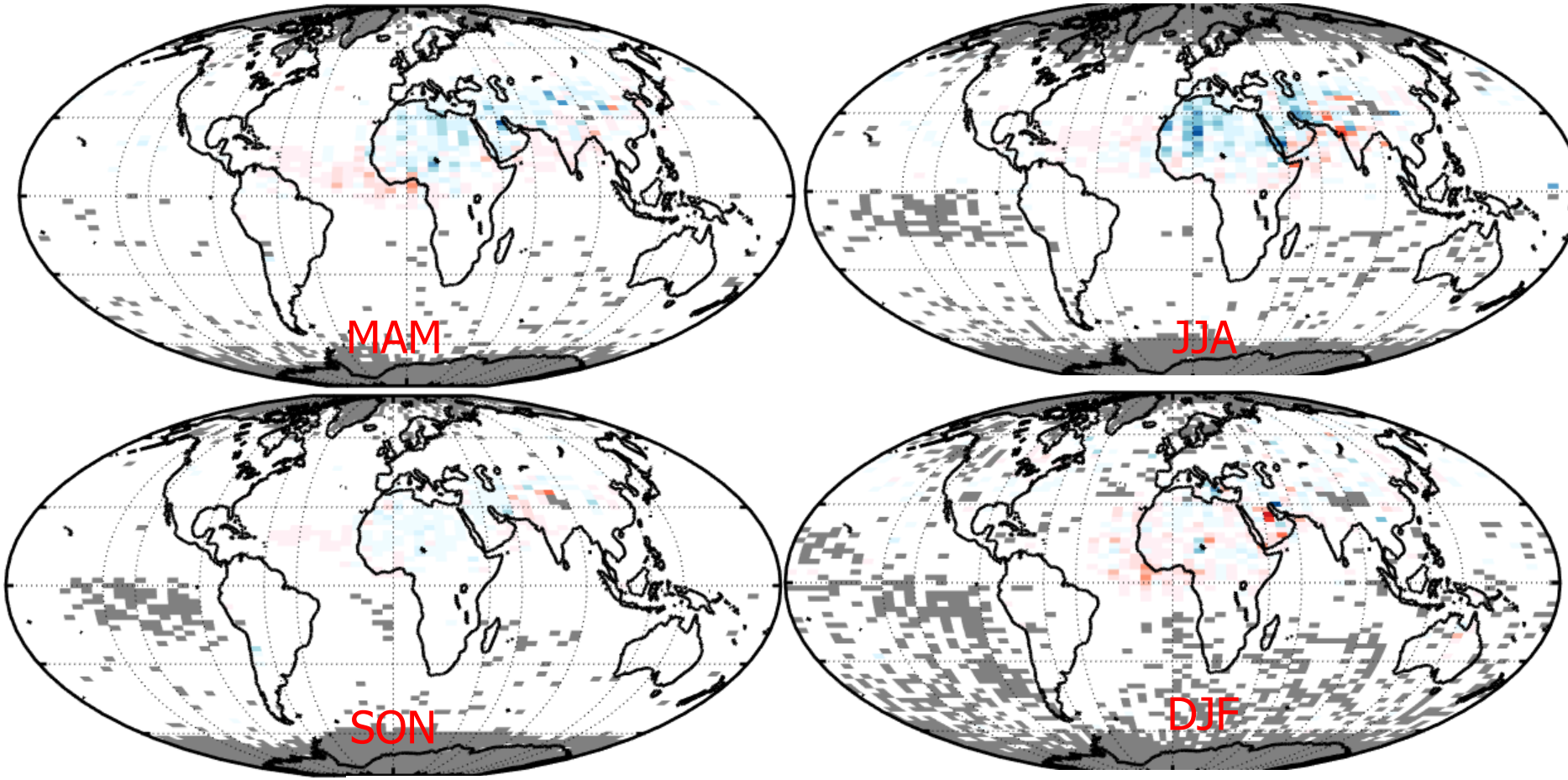
Mean Seasonal Dust Daytime Dust AOD (2006-2015)



Mean Monthly Nighttime Dust AOD (2006-2015)

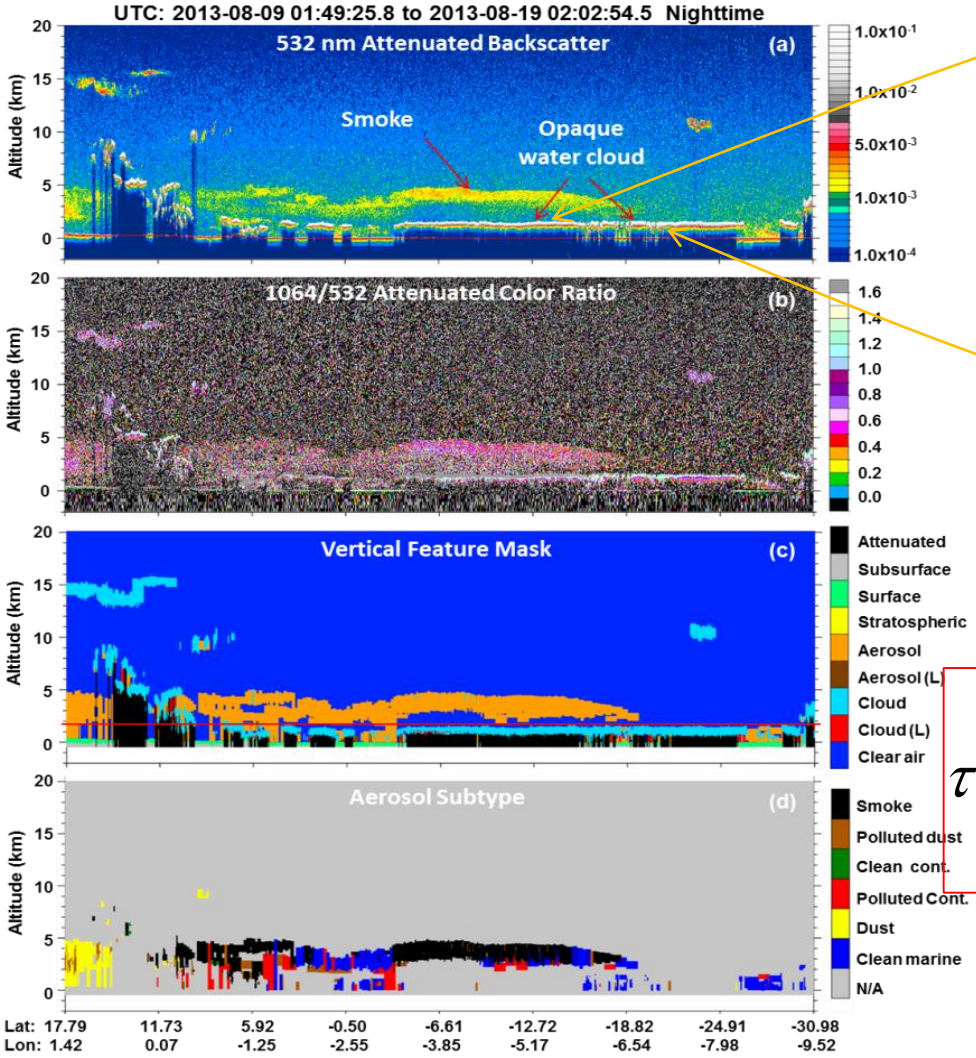


Seasonal Diurnal AOD Differences



Opaque Water Cloud Constrained Retrievals

(Hu et al. 2007)



$$\tau_{aerosol} = -\frac{1}{2}\ln\left(\frac{\gamma'_{WC,SS}}{\gamma'_{WC,SS,NA}}\right)$$

WC = above Water Cloud
SS = Single Scattering
NA = No Aerosol

$$\frac{\gamma'_{WC,SS}}{\gamma'_{WC,MS}} = \left(\frac{1-\delta_I}{1+\delta_I}\right)^2$$

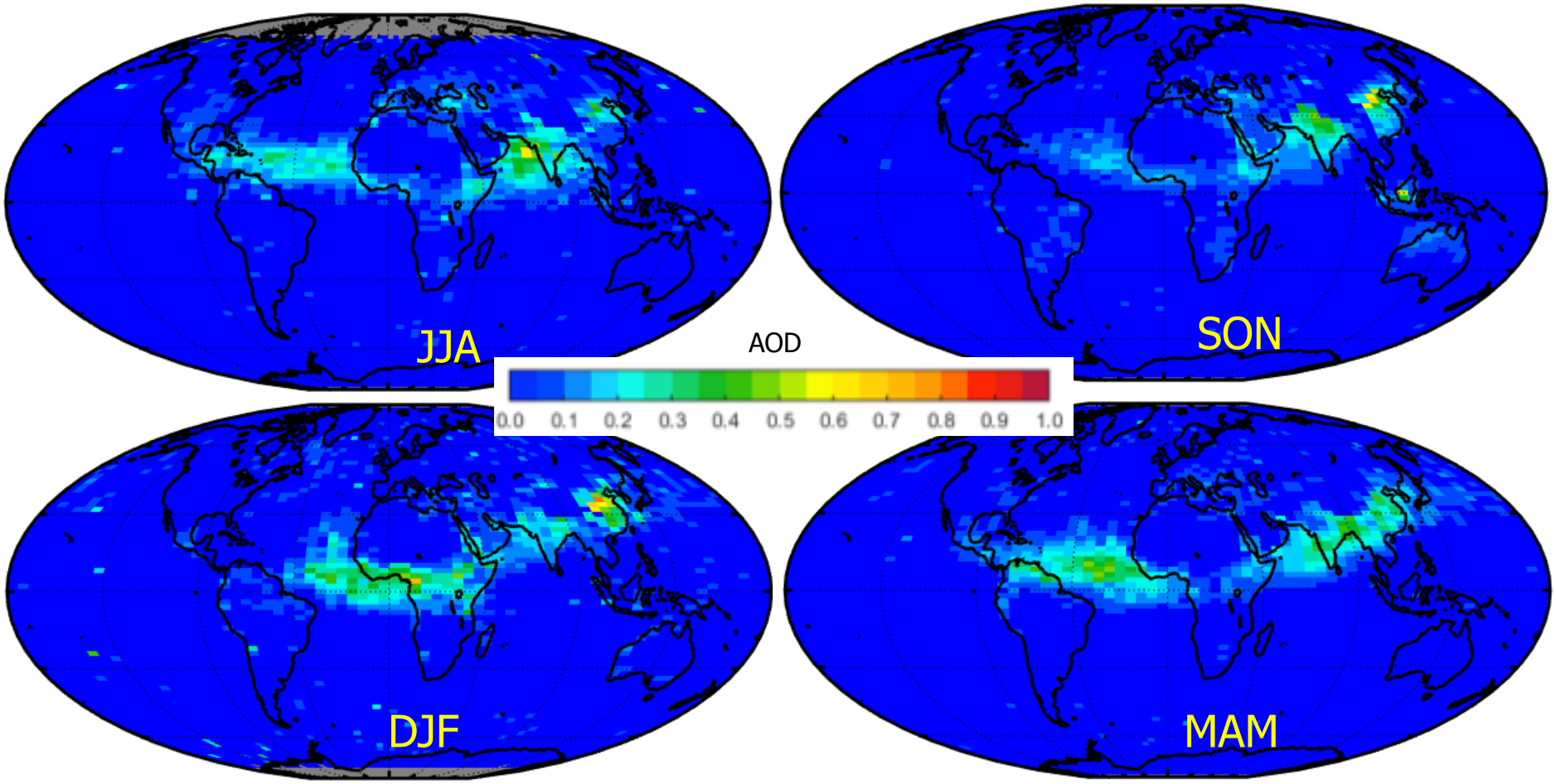
δ_I *= layer integrated depolarization ratio*

$$\tau_{aerosol} = -\frac{1}{2}\ln\left(2S_{WC}\gamma'_{WC,MS}\left(\frac{1-\delta_I}{1+\delta_I}\right)^2\right)$$

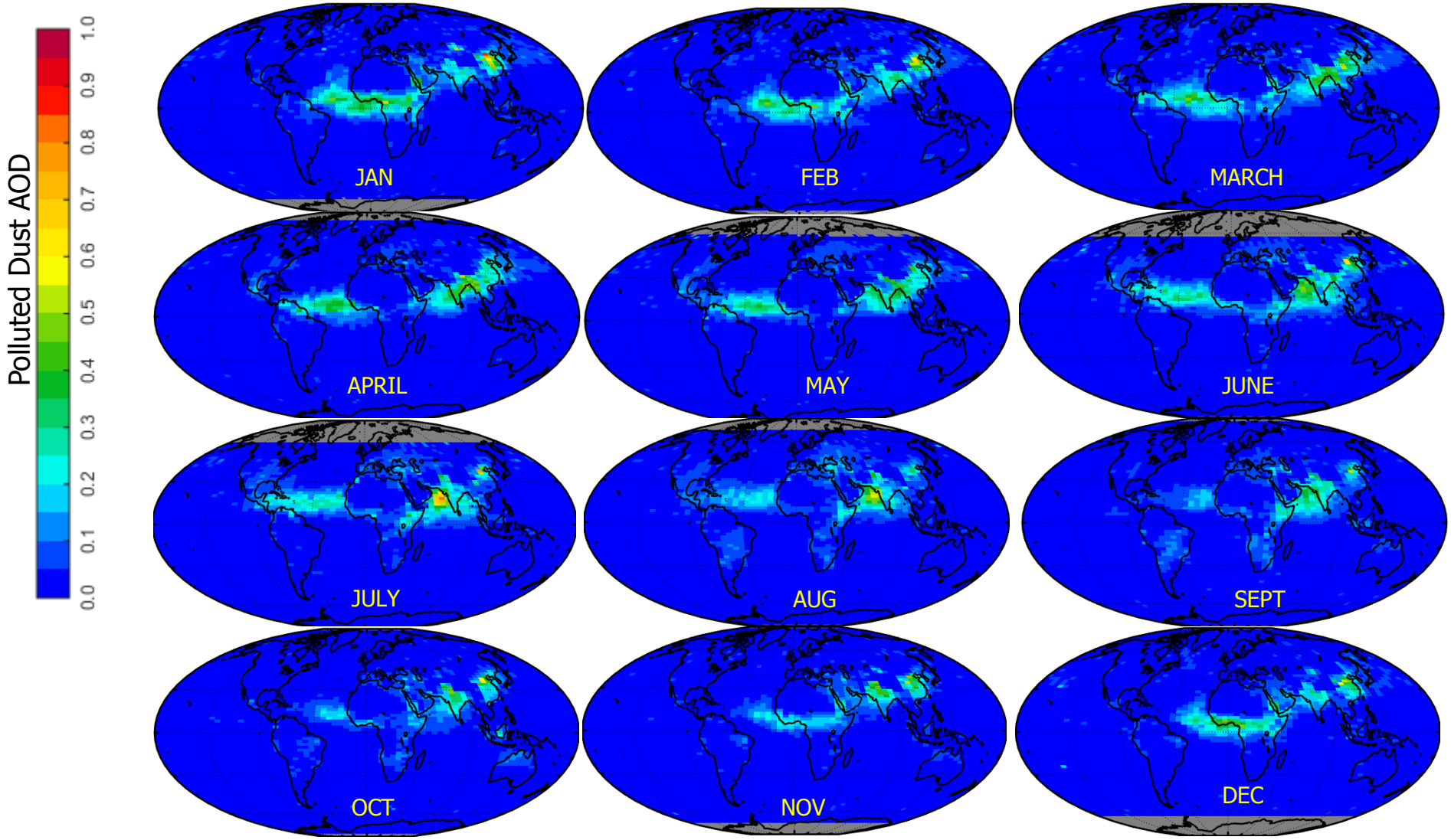
$S_{WC} \cong 18.9$ sr $\pm$ 0.25 sr (Hu et al. 2006)

Liu et al. 2014 ACP)

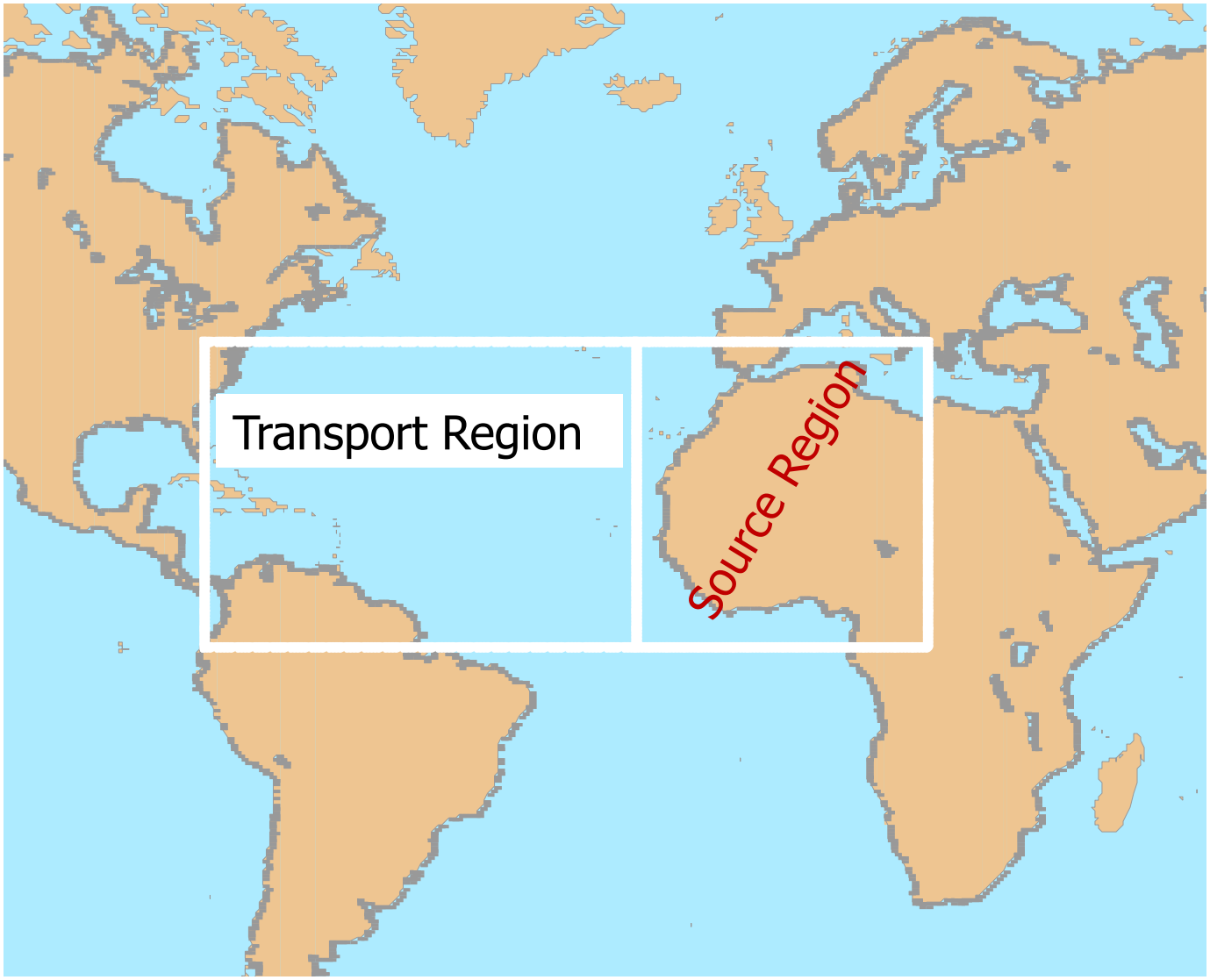
Mean Seasonal Nighttime Polluted Dust AOD (2006-2015)



Mean Monthly Nighttime Polluted Dust AOD (2006-2015)



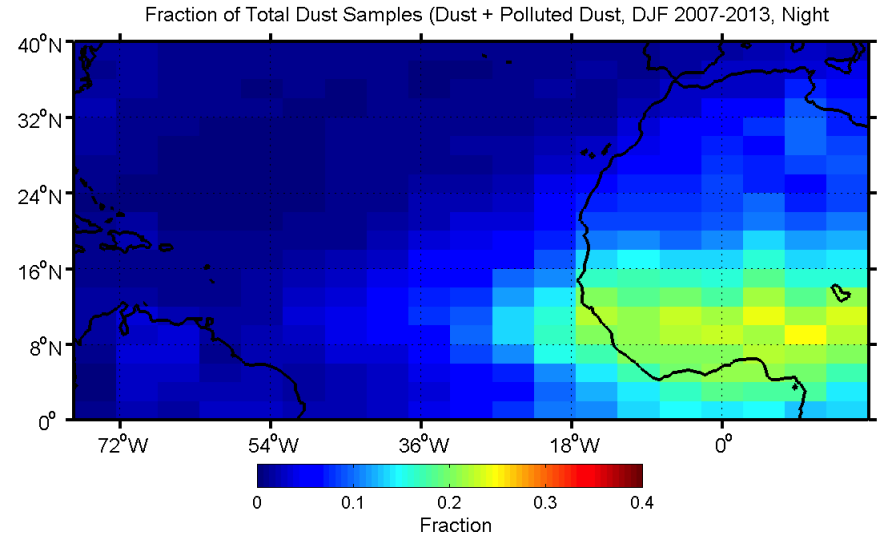
Study Domains: Source and Transport Regions

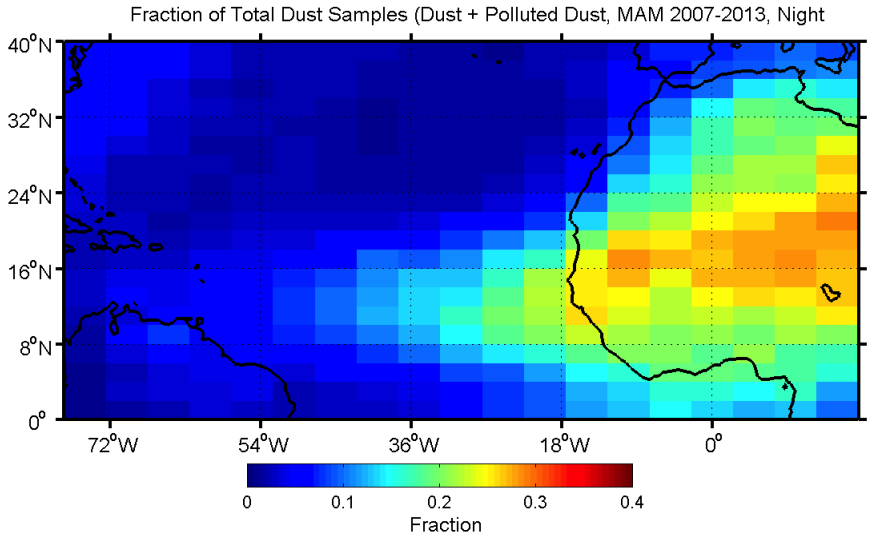


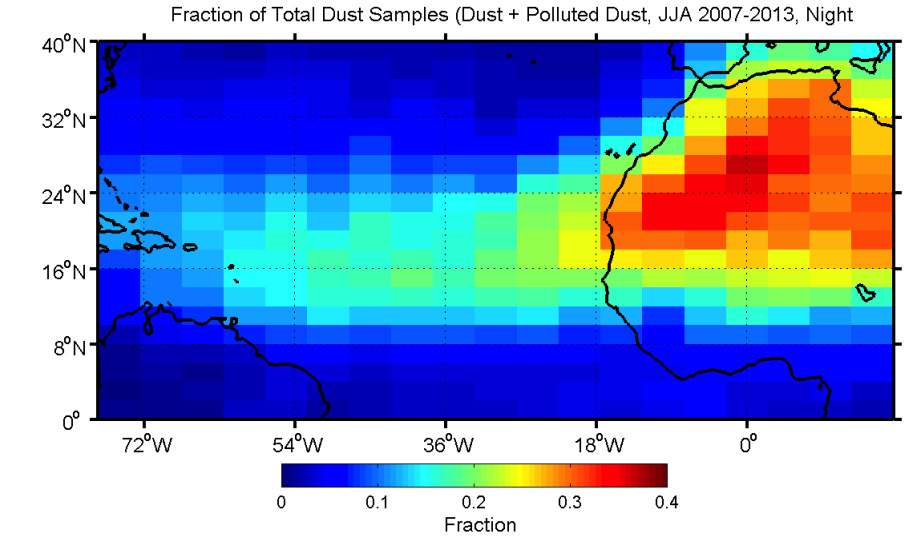
source (Lat 0° to 40° Lon -20° to 20°)

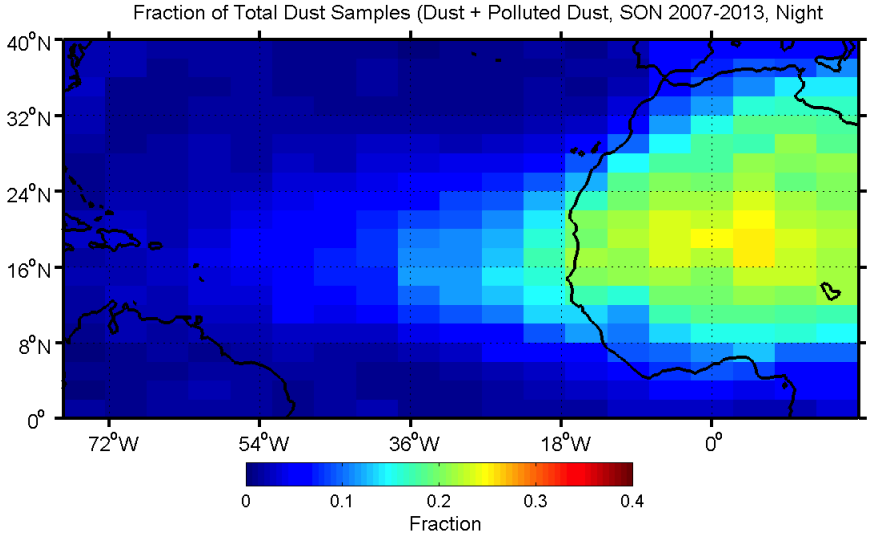
transport region (Lat 0° to 40° Lon -80° to -20°)

Seasonal Fraction Saharan Dust Aerosol Layers (2007-2013)





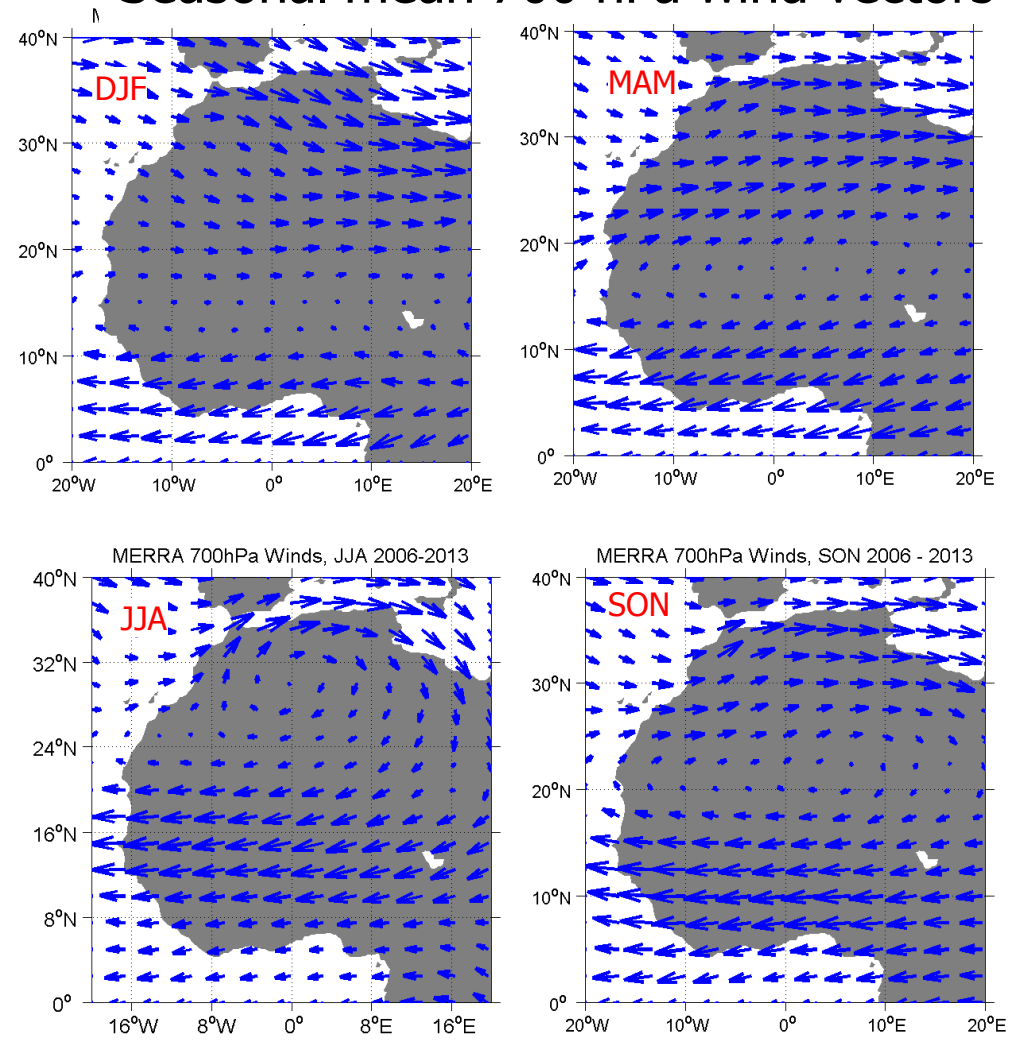


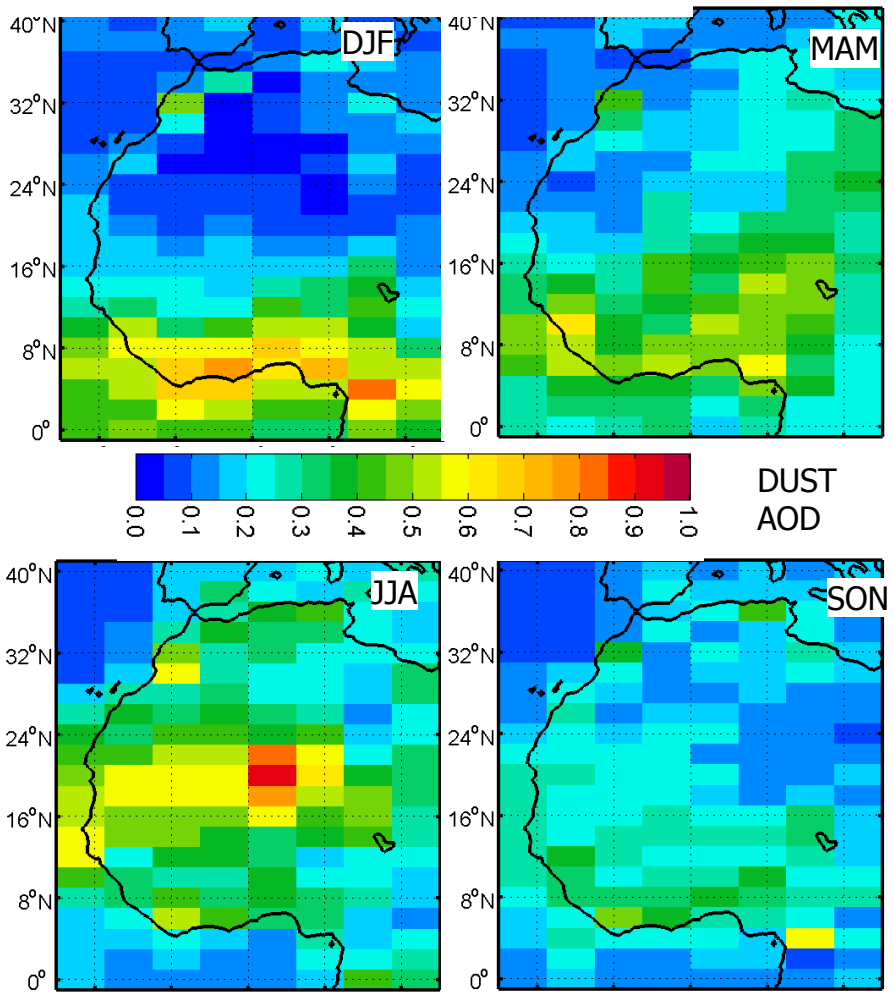


Fraction = {Dust + Polluted Dust}/{All Aerosol Layers}

MERRA Winds and Dust AODs

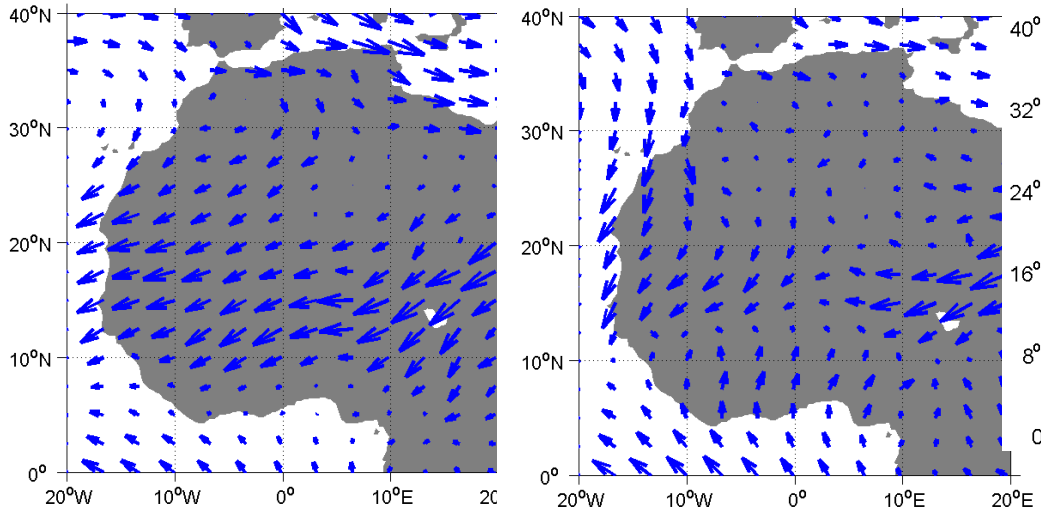
Seasonal mean 700 hPa wind vectors for 2006-2013 from MERRA

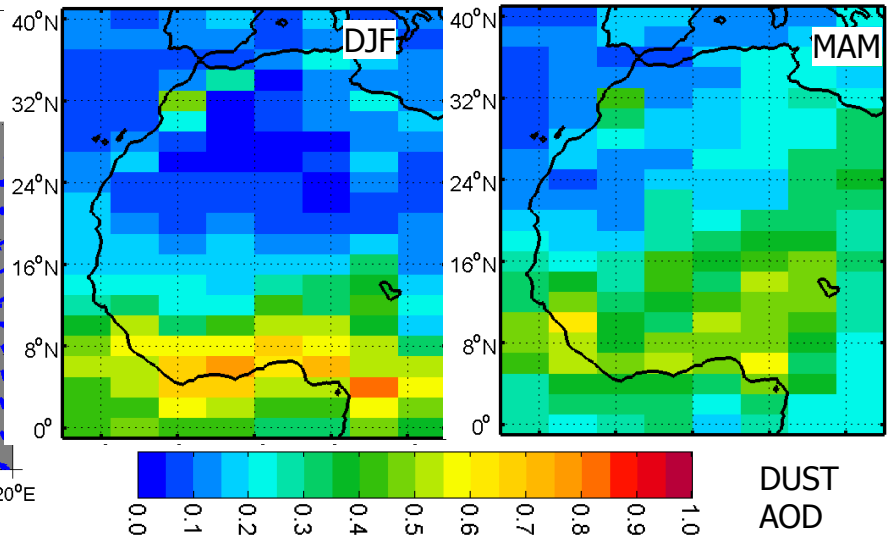




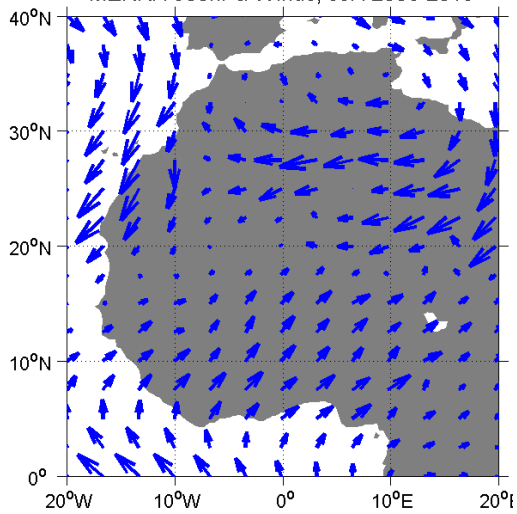
MERRA monthly analysis data were provided by the Giovanni online data system, developed and maintained by the NASA GES DISC

Seasonal mean 900 hPa wind vectors for 2006-2013 from MERRA

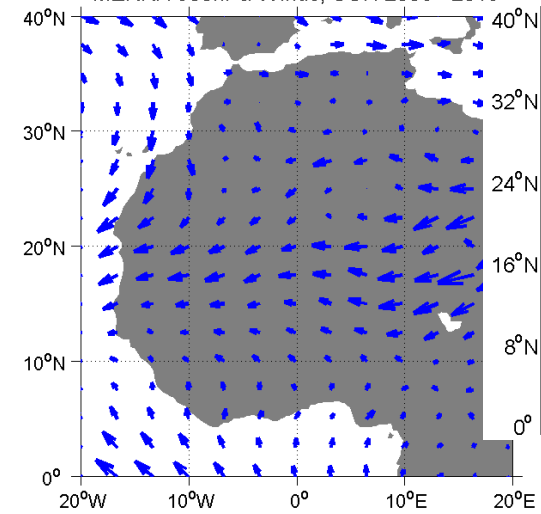


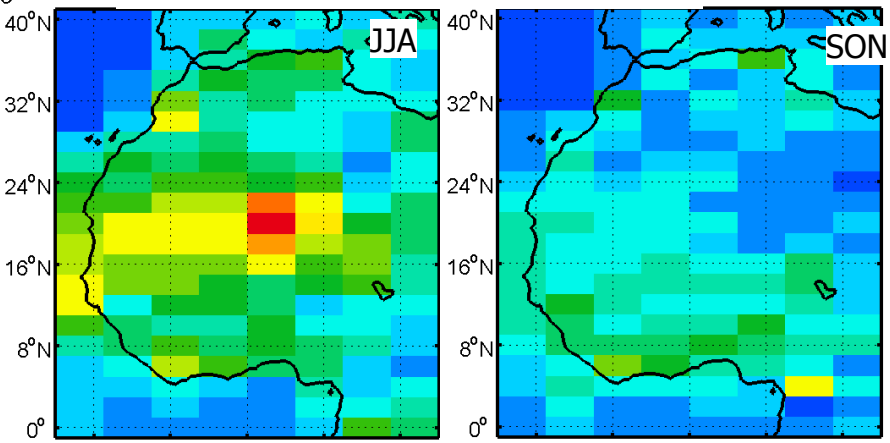


MERRA 900hPa Winds, JJA 2006-2013



MERRA 900hPa Winds, SON 2006 - 2013





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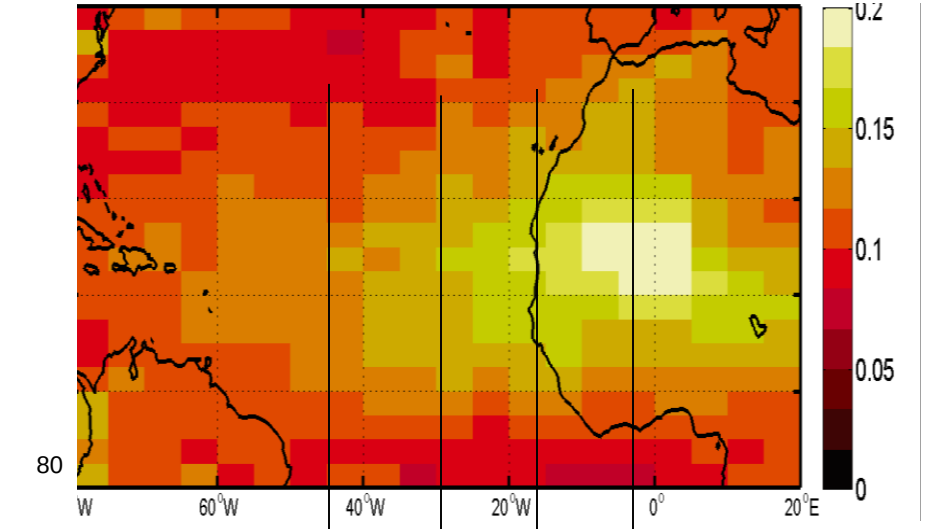
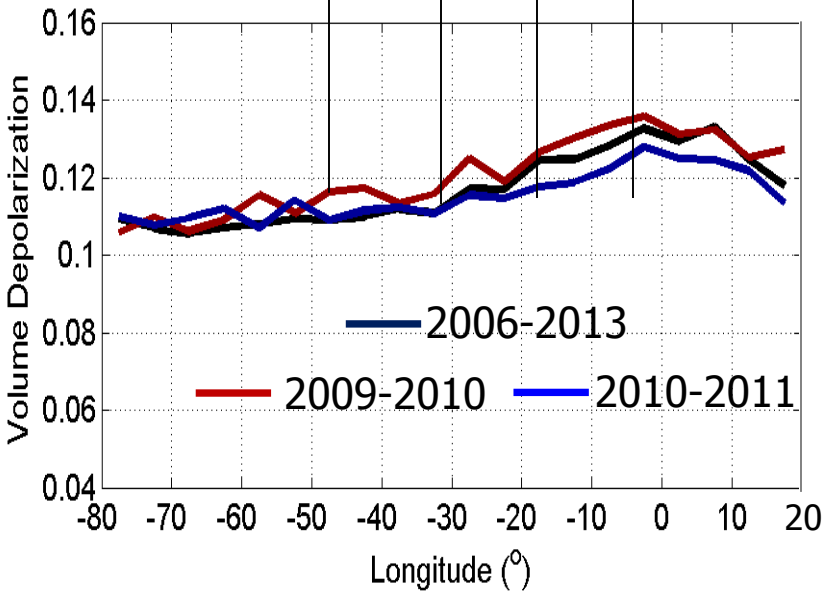
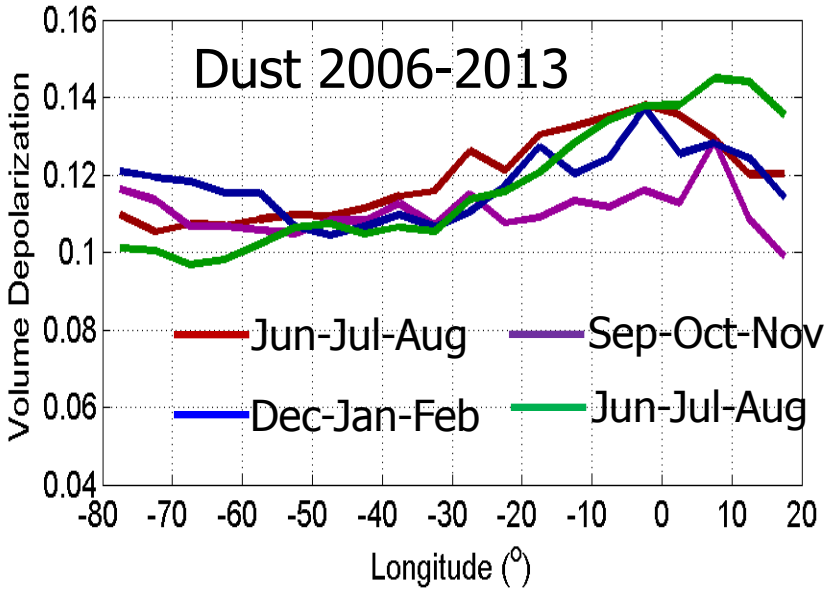
Changes in pure dust particle shape



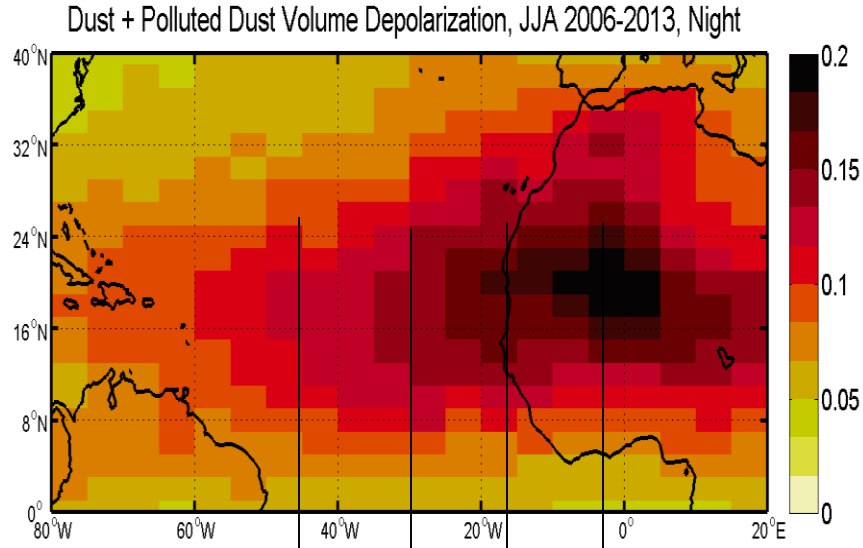
The dust volume depolarization ratio is fairly uniform throughout the source and transport regions

VDR is varies between 0.14 to 0.11 from the source to the transport regions



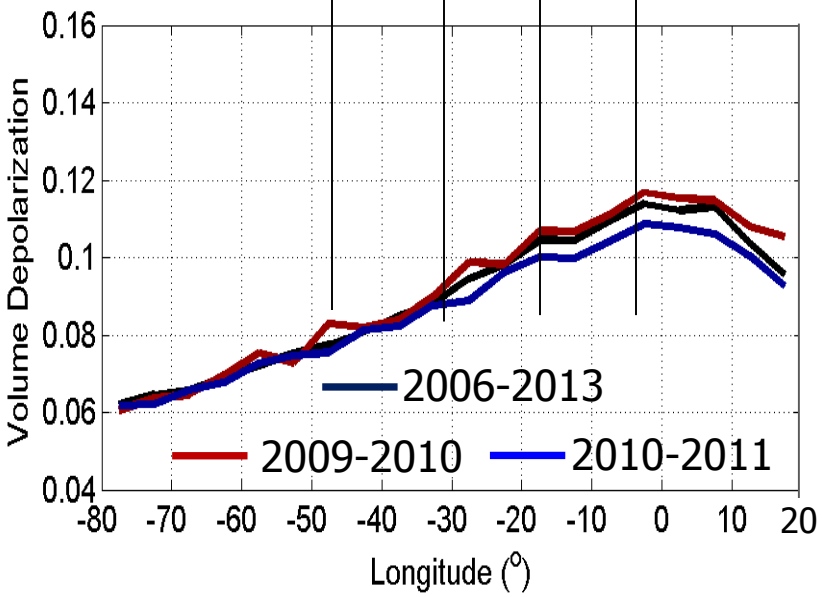


Changes in mixed dust particle shape

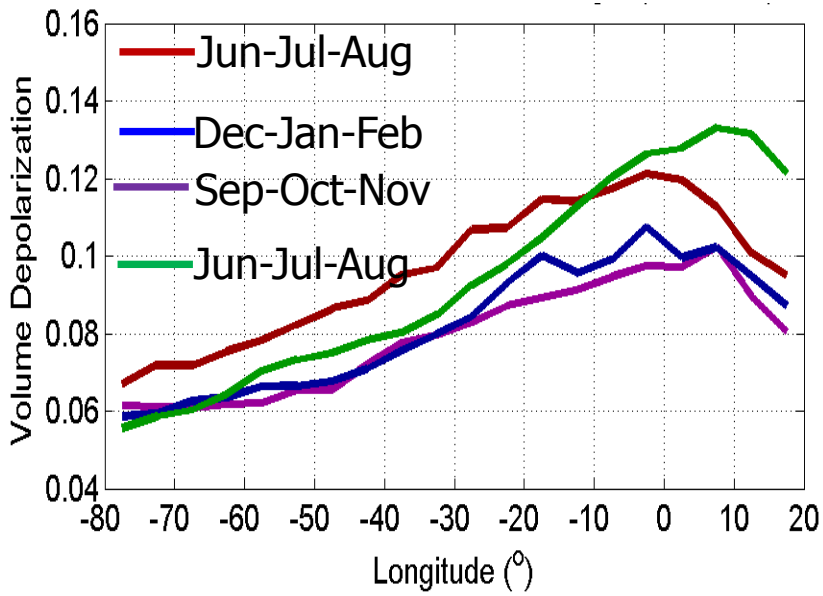


Off the coast the VDR decreases linearly with distance away from the source

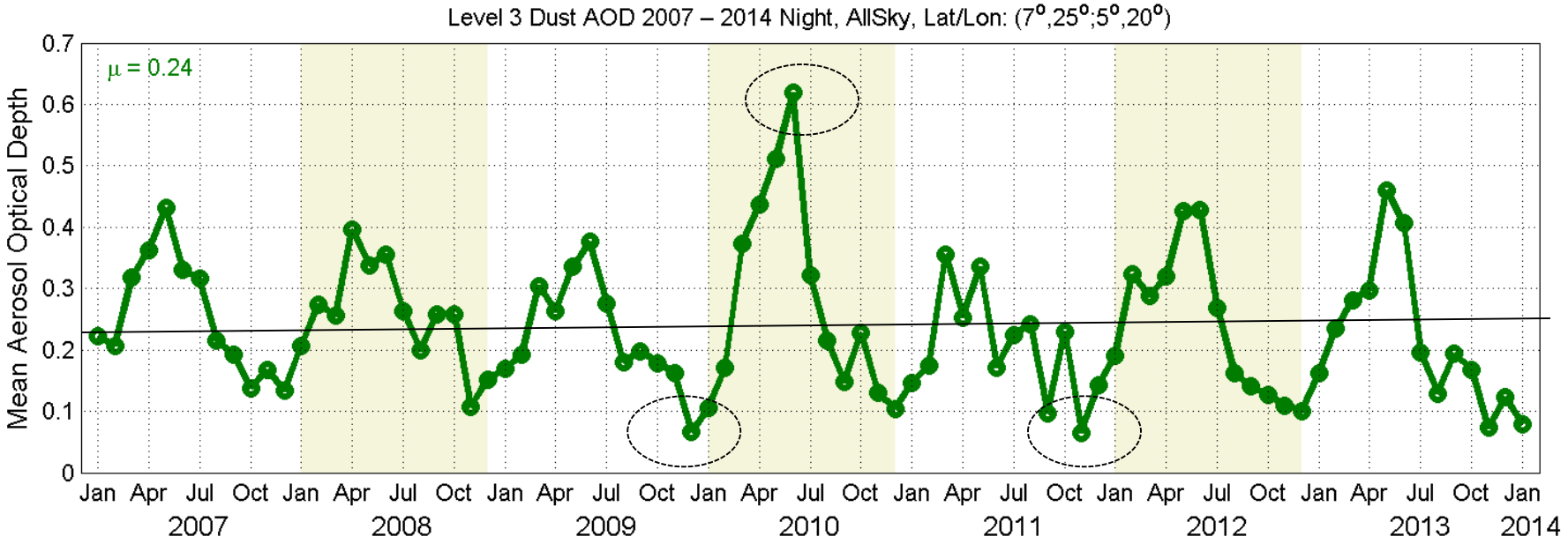
VDR is varies between 0.12 to 0.06 from the source to the transport regions



2006-2013



Nighttime Dust AOD Monthly Time Series [2007 – 2014]



The monthly maximum is in June 2010 (~0.62) and the minima in Dec 2009 and Nov 2011 (~0.066)